

**FERTILIZER PATTERN ANALYZER
USING MICROSOFT EXCEL**
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$$CV = \frac{\text{standard deviation}}{\text{average}} \times 100 \quad \text{Equation 2}$$

Abstract

Xlfert is a Microsoft Excel application that analyzes the spread pattern of a fertilizer spreader. Xlfert is derived from a legacy DOS program called FERT developed by Randy Loper at the Mississippi Cooperative Extension Service of Mississippi State University. Xlfert takes the data gathered from a spreader test and interpolates it using the cubic spline function from XIXtrFun, a library developed by Scott Allen Rauch of Advanced Systems Design and Development, to produce a smooth initial pattern. The interpolated data is then overlaid to simulate the “racetrack” and “up/down” methods of spreading to produce composite patterns of which the analyses are based on. Summary statistics including maximum, minimum and average pounds per acre, coefficient of variation, and standard deviation are calculated for both methods. This program also graphs the overlay data for the swath width(s) that the user selects.

Introduction

Xlfert uses the spread pattern test method specified in the ASAE Standards (ASAE 1999). For this test, an odd number of pans are used to collect the samples of fertilizer. These pans are placed in a row that is perpendicular to the spreader's route. The spreader travels through the center of a row once and the fertilizer that is collected in the pans are weighed. The application rate is calculated using Equation 1:

$$\text{Rate} = \frac{13829 \times \text{mass}}{\text{area of pan} \times \text{efficiency}} \quad \text{Equation 1}$$

where rate is pounds per acre, mass is in grams, and the area of the pan is in square inches. The efficiency is assumed to be 100% in Xlfert.

There are two ways to spread fertilizer: racetrack and up/down. Racetrack means that the spreader is driven in only one direction and up/down means the spreader is driven in alternating opposite directions. Finding the most effective swath width is the goal of a fertilizer spreader pattern test. The most effective swath width has the widest possible width and the smallest coefficient of variation (CV).

Methods and Procedures

A sample test will be described to explain the methods and procedures by which Xlfert analyzes the spread pattern.

For this example, a row of 10 pans will be used to collect the spread samples. The spacing between two pans is 2 feet, which results in a total width of 18 feet. The collected sample weights are shown in column 3 of the table in Figure 1. The total number of feet covered by the pans is calculated using Equation 3.

$$\text{total width} = (\text{number of pans} - 1) \times \text{pan spacing} \quad \text{Equation 3}$$

Xlfert interpolates the initial data to produce an interpolated series (column 4). The pound-per-acre values are computed using Equation 1, and the results are shown in column 5 of Figure 1. The interpolated data is then overlaid over itself with a given amount of offset (beginning overlay distance). The sum of data points at each swath position produces a new composite data set shown in column 6 of the table in Figure 4. The overlaying and summing processes are done repeatedly until a repeating pattern in the new composite data set is produced. Figure 4 shows the interpolated data being overlaid 3 times to produce the repeating pattern. The length of the new data set will be the total width computed from the number of pans (18 feet). The summary statistic is computed once the overlaying process is complete. The computation of summary statistics is done for every set of overlay. The user determines how many times the summary statistics are to be computed by specifying the number of overlays. Each subsequent summary statistics is computed based on a new overlay distance, which is the previous overlay distance plus the overlay increment that the user specifies. Upon completion of its computation, Xlfert produces graphs showing the spread pattern.

The User Interface Forms of Xlfert

The user interface of Xlfert consists of three forms: Settings, Data, and Graph forms.

Xlfert has a pre-configured set of Excel worksheets described below:

- *Intro*: the "start" button is located here.
- *Help*: a reference for the program; forms, buttons, sheets, and tips are described here.
- *Record*: the user can keep his/her raw data here; the CLEAR button does not affect this sheet. The

user can use the "cut", "copy", and "paste" functions to move the data to this sheet.

- *Settings*: lists the parameters set in a previous run.
- *Data*: shows the raw data entered by the user.
- *Results racetrack*: shows the overlaid data for the racetrack method.
- *Results up/down*: shows the overlaid data for the up/down method.
- *Statistics racetrack*: shows the maximum, minimum, and average pounds per acre, the standard deviation, and the coefficient of variation for the racetrack method.
- *Statistics up/down*: shows the maximum, minimum, and average pounds per acre, the standard deviation, and the coefficient of variation for the up/down method.
- *Preview*: allows the user to offset the data to the left or right before the data undergoes the overlaying process. The user can also reset the data to its original values. This sheet is only visible when the user presses the "preview" button in the Data Entry Form; this sheet is hidden the rest of the time.

Settings Form

The Settings Form is the main form of Xlfert; it is the form that defines how the pattern analysis is done.

The Settings Form is shown in Figure 3. All of the text boxes in the form must be completed before the program will run. The functional descriptions of the text boxes are as follows:

- *Pan spacing*: the distance in feet between the centers of two consecutive pans.
- *Pan Area*: the area in square inches of each pan.
- *Beginning Overlay Distance*: the initial overlay distance, in feet, between two consecutive swaths.
- *Overlay Increment*: the number of feet to increase the overlay distance every time a new computation is to be done.
- *Number of Overlays*: the number of times different overlays are applied to a run.
- *Number of Pans*: the number of pans in one row.
- *Number of Runs*: the number of times the spread pattern test is done.

The buttons in the form are described below.

- *Clean Sheets*: clears all the sheets except for the intro, help, and record sheets.
- *Data Entry*: opens the data entry form (Figure 5).
- *Analysis*: analyzes the data by interpolating the data, overlaying the data using both the racetrack

method and up/down method, and calculates the statistics of both methods.

- *Graphing*: opens the graph form (Figure 6).
- *Finish*: exits the program and takes the user to the Microsoft Excel workbook.

Data Entry Form

The Data Entry Form shown in Figure 5 is for the data that is collected from the pans of the spreader pattern test. The maximum number of pans that can be entered in Xlfert is 50. The weight unit assumed for the data in this form is grams. The run number is at the top left of the form; it will increment every time the user saves data and presses the clear entry button, or the user can enter in a run number.

The buttons of the data entry form are described in the following sentences.

- *Save Data*: must be clicked on after the user has finished entering all the data for one run; the saved data is put in the data sheet.
- *Clear Entry*: clears all of the boxes so that the user can enter in new data. Once this button is clicked, the run number is automatically incremented by one.
- *Done*: closes the data entry form and takes the user back to the settings form.
- *Preview*: takes the user to the preview sheet and allows the user to see a graph of the raw data. The user can move the graph to the left or right by specifying the numbers in the "right" or "left" boxes on the preview buttons shown in Figure 2. The refresh button graphs the original data.

Graphing Form

The Graphing Form shown in Figure 6 allows the user to choose the swath width to graph. All of the swaths are listed with their CV's. The user can also delete swaths in the list by selecting the desired swath and pressing the delete button. Once all the desired graphs are selected, the user can press the graph button, which will cause the program to end and the graphs will show up in the excel workbook.

If the user would like to see some more graphs of other swaths after he or she has already graphed, the user can just click on the graph button on the main form and select the swath he or she would like to see graphed.

Conclusion

Xlfert is an extensible application; it is "friendlier" than its predecessor. All the data entered by the user and the data generated by Xlfert are in the spreadsheet. This simplifies the use of the data into different software packages that the user may have. The user can extend the functionality of this

application by adding new functions in the future. One of the possibilities is to allow the program to read in the masses of the fertilizer automatically from the scale so that the user does not have to enter them in manually. Another possibility is to make Xlfert internet-based so that it can be used by users who do not have Microsoft Excel in his/her local computer. The internet site at which Xlfert is available to be downloaded is <http://www.abe.msstate.edu/~tools>.

References

Fertilizer Application Subcommittee of ASAE Agricultural Chemical Application Committee. Procedure for Measuring Distribution Uniformity and Calibrating Granular Broadcast Spreaders. ASAE Standards. 46th Edition, 1999, S341.3, pp. 188-191.

Distance (feet)	Pan Number	Mass in Grams	Interpolated Data	Data Converted to lbs/acre
Pan Spacing 2 feet	0 Pan 1	1	1	64.02314815
	1		1.49858490	95.94412343
	2 Pan 2	2	2	128.0462963
	3		2.50424528	160.3296668
	4 Pan 3	3	3	192.0694444
	5		3.48443396	223.0844318
	6 Pan 4	4	4	256.0925926
	7		4.55801886	291.8187172
	8 Pan 5	5	5	320.1157407
	9		5.15849056	330.2628057
	10 Pan 6	5	5	320.1157407
	11		4.55801886	291.8187172
	12 Pan 7	4	4	256.0925926
	13		3.48443396	223.0844318
	14 Pan 8	3	3	192.0694444
	15		2.50424528	160.3296668
	16 Pan 9	2	2	128.0462963
	17		1.49858490	95.94412343
	18 Pan 10	1	1	64.02314815

Figure 1. Example Data Collected in a Test.

Left

Right

REFRESH

DONE

Note: Put 0 in both boxes to view original data

Figure 2. Preview Buttons.

XLFERT Main Window
Settings

Pan Spacing (ft)

Pan Area (in^2)

Beginning Overlay Distance (ft)

Overlay Increment (ft)

Number of Overlays

Number of Pans

Number of Runs

Clear Sheets

Data Entry

Analysis

Graphs

Finish

Status:

Figure 3. Settings Form.

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Feet					Sum of the arrays
0	64.023				64.023
1	95.944				95.944
2	128.05				128.05
3	160.33				160.33
4	192.07				192.07
5	223.08				223.08
6	256.09				256.09
7	291.82				291.82
8	320.12				320.12
9	330.26				330.26
10	320.12	64.023			384.14
11	291.82	95.944			387.76
12	256.09	128.05			384.14
13	223.08	160.33			383.41
14	192.07	192.07			384.14
15	160.33	223.08			383.41
16	128.05	256.09			384.14
17	95.944	291.82			387.76
18	64.023	320.12			384.14
19		330.26			330.26
20		320.12	64.023		384.14
21		291.82	95.944		387.76
22		256.09	128.05		384.14
23		223.08	160.33		383.41
24		192.07	192.07		384.14
25		160.33	223.08		383.41
26		128.05	256.09		384.14
27		95.944	291.82		387.76
28		64.023	320.12		384.14
29			330.26		330.26
30			320.12	64.023	384.14
31			291.82	95.944	387.76
32			256.09	128.05	384.14
33			223.08	160.33	383.41
34			192.07	192.07	384.14
35			160.33	223.08	383.41
36			128.05	256.09	384.14
37			95.944	291.82	387.76
38			64.023	320.12	384.14
39				330.26	330.26
40				320.12	320.12
41				291.82	291.82
42				256.09	256.09
43				223.08	223.08
44				192.07	192.07
45				160.33	160.33
46				128.05	128.05
47				95.944	95.944
48				64.023	64.023

**Beginning Overlay
Distance =10 feet**
swath width of 10 feet

**Beginning
Overlay
Distance
(10 feet)**

**Beginning
Overlay
Distance
(10 feet)**

new
summing
data set

Figure 4. Example of an Orderly Process.

F
i

Data Entry Form

Weight should be in grams

Run #

Pan Number and Weight

1	2	3	4	5	6	7	8	9	10
<input type="text" value="1"/>	<input type="text" value="2"/>	<input type="text" value="3"/>	<input type="text" value="4"/>	<input type="text" value="5"/>	<input type="text" value="5"/>	<input type="text" value="4"/>	<input type="text" value="3"/>	<input type="text" value="2"/>	<input type="text" value="1"/>

Figure 5. Data Entry Form

Graph

GRAPHING

Select the CV's to Graph

List of CV's to Graph

Maximum number of graphs = 25

- Racetrack, Run 1, swath 12, cv = 3.7118710795800
- Racetrack, Run 1, swath 14, cv = 12.678109013057
- Updown, Run 1, swath 10, cv = 4.4432959226398

Figure 6. Graphing Form